

## Global Precipitation at Your Fingertips, Part I: Data

George J. Huffman<sup>1,2</sup>

1: NASA Goddard Space Flight Center, Laboratory for Atmospheres

2: Science Systems and Applications, Inc.

submitted to *The Pacific Tradewinds Quarterly*

28 May 2010

Rev. 30 June 2010

How much precipitation fell last month around the entire globe, or even in your area? What's the long-term average? What are the important year-to-year fluctuations? It is no surprise to this newsletter's readers that these are hard questions because most of you live on small islands and know first-hand that the ocean has a nearly total lack of surface data. It has been clear from the dawn of the Space Age that satellites provide an excellent platform to address this problem, but it was not until the late 1970's that the first generation of sensors was continuously available in space to start the precipitation record. It took another 15 years and a second generation of satellite-based sensors for scientists to develop the first long-term global precipitation data set that took advantage of these then-new satellite data. At the same time, research showed that raingauge data continued to be very important, both for use with the satellite data and for independent comparisons to the final precipitation products. This article will describe a few widely available precipitation data sets, while a companion article in the next newsletter will introduce you to a freely accessible World Wide Web site that allows simple interactive display and analysis of these and other data.

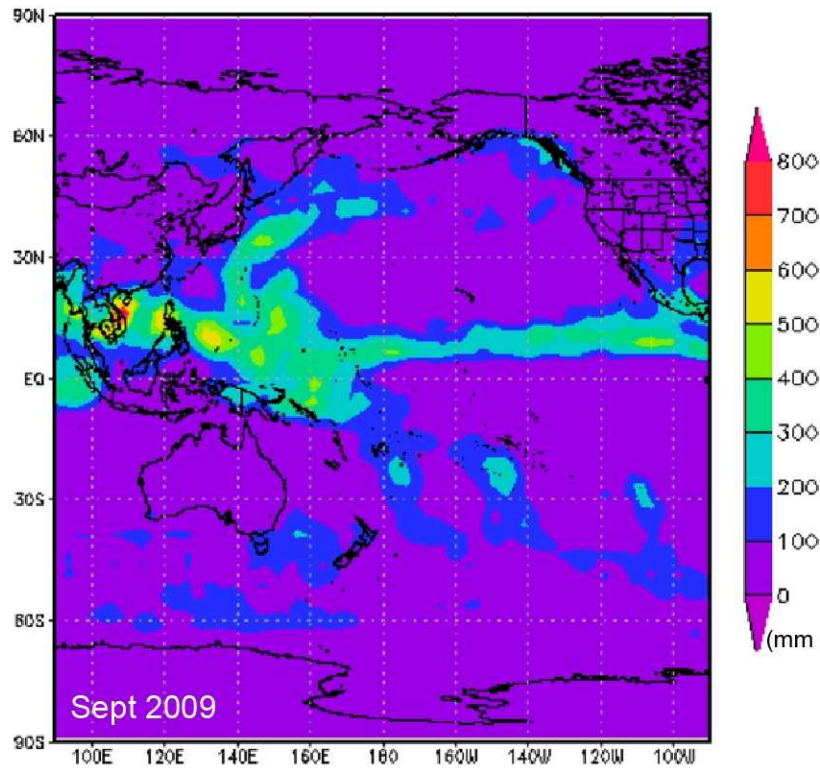
The most accurate satellite estimates come from the first precipitation radar (PR) to fly in space, aboard the Tropical Rainfall Measuring Mission (TRMM) satellite. Although important for research, the PR's coverage is too limited to give routine monitoring of global precipitation. Rather, we depend on observations of the Earth system's natural emission of microwave energy. Even these data are not available at all times since the satellites on which the microwave sensors fly are in "low Earth orbit", or LEO, some 400-800 km above the surface. Such LEO satellites pass over any given spot on Earth twice a day. In contrast, "geosynchronous Earth orbit", or GEO, satellites at an altitude of about 35,000 km orbit at the same speed that the Earth revolves and therefore always view the same part of the surface. The trade-off is that GEO sensors provide less-precise estimates computed from the Earth system's natural emissions of infrared (IR) energy. Other satellite datasets are used to provide estimates in regions where both microwave and IR have difficulty, such as polar regions or times before mid-1987 when microwave data became available. Finally, rain gauge data where available, have proved to be valuable for helping to reduce biases in the satellite data, which are persistent differences between the satellite estimate and the precipitation that actually occurred. The datasets discussed below take slightly different approaches to mixing and matching the various kinds of input data to create global estimates of precipitation that answer different needs and/or take advantage of different input data. Each is produced at the NASA Goddard Space Flight Center, in Greenbelt, Maryland, USA. [Other combination datasets are produced at other data centers.]

The longest-running dataset, beginning with 1979, is the monthly satellite-gauge combined dataset produced as part of the Global Precipitation Climatology Project (GPCP). The GPCP is an international project whose ultimate reporting authority is the World Meteorological Organization. The gridbox size is relatively coarse,  $2.5^{\circ} \times 2.5^{\circ}$  of latitude/longitude. In the SPaRCE region, the data are mostly created by calibrating the IR data to the microwave satellite closest to the 6 a.m. / 6 p.m. overpass time. Another way of saying this is that we try to develop equations that make the average behavior of IR-based precipitation estimates as much like the microwave-based estimates at 6 a.m. / 6 p.m. as possible. Then we apply those equations to all of the IR data for the entire day. As a last step, these microwave-calibrated IR estimates are added up for the month and combined with raingauge data over continental regions to compute the final satellite-gauge product.

Three combination data sets are produced as part of the highly successful TRMM, which is a joint NASA – Japanese Aerospace Exploration Agency satellite mission. These data sets are created at much finer time and space scales than the GPCP data, but for a shorter period and only the tropical and subtropical regions. The general algorithm name is TRMM Multi-satellite Precipitation Analysis, and the various datasets are given different product numbers to help keep straight which one is being used. The first is 3B42, which is computed on a 3-hourly,  $0.25^{\circ} \times 0.25^{\circ}$  latitude/longitude grid for the period 1998 to the present. Unlike the GPCP product all available microwave data are used, first to calibrate the IR and second directly to make the estimates. Gridboxes that lack microwave data for a given 3-hour period are given an IR estimate. All 3-hourly data in a month are added up and combined with monthly raingauge data, similar to the GPCP procedure, to create the TMPA monthly product, 3B43. Then we go back and the 3B42 3-hourly estimates are all slightly inflated or deflated so that they add up to the monthly 3B43 value, gridbox-by-gridbox. The third product is computed separately about 6-9 hours after observation time, rather than waiting for the end of the month. This “real-time” product, 3B42RT, is similar to the first part of 3B42, but then the final adjustment is done using long-term average relations to 3B43 instead of computing a new adjustment each month. The goal for 3B42RT is to give a same-day estimate of the global precipitation for short-term monitoring of floods, droughts, crop development, and other rapid-update issues.

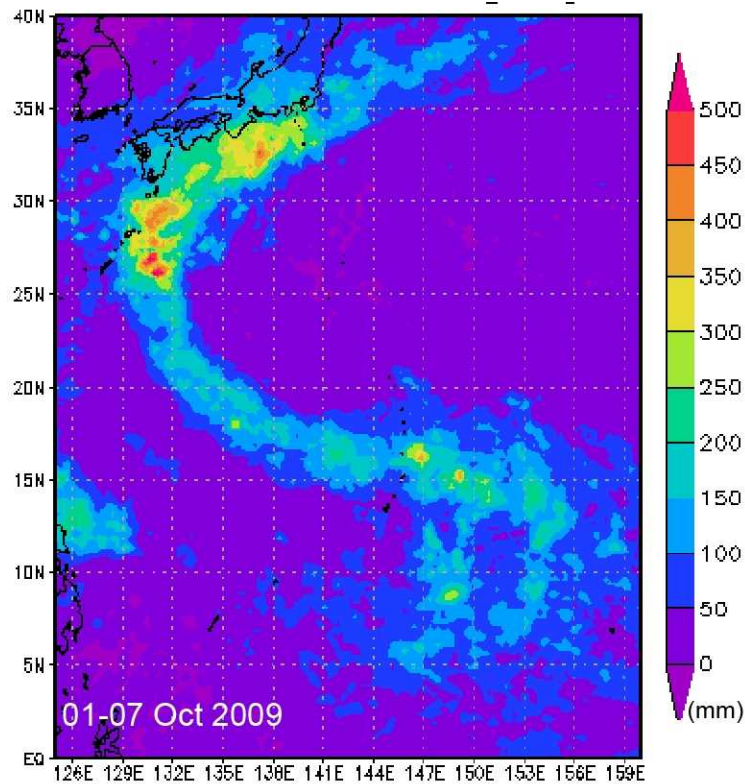
The accuracy of these data sets depends on several factors, including the particular sensor(s) and algorithm(s) used to compute the precipitation, the general type of weather (widespread or spotty showers, deep or shallow clouds, etc.), the underlying surface (land, ocean, coast, or ice, and how flat the land, coast, and ice are), and how large a time/space average is considered. The issue of averaging becomes particularly important when one tries to compare the record at a single gauge against the record for a single gridbox from one of the data sets – individual days will probably show large disagreements, with monthly accumulations agreeing better, seasons even better, and so on.

To get started using these datasets, go to the NASA/Goddard group’s Web page, <http://precip.gsfc.nasa.gov>, for access to the data, technical documentation, pointers to the published papers, and lists of papers that use the data sets. As well, these data sets and others can be displayed and analyzed using the TRMM On-line Visualization and Analysis System (TOVAS) at <http://disc2.nascom.nasa.gov/tovas/>. The next newsletter will feature an article introducing TOVAS and providing some examples.

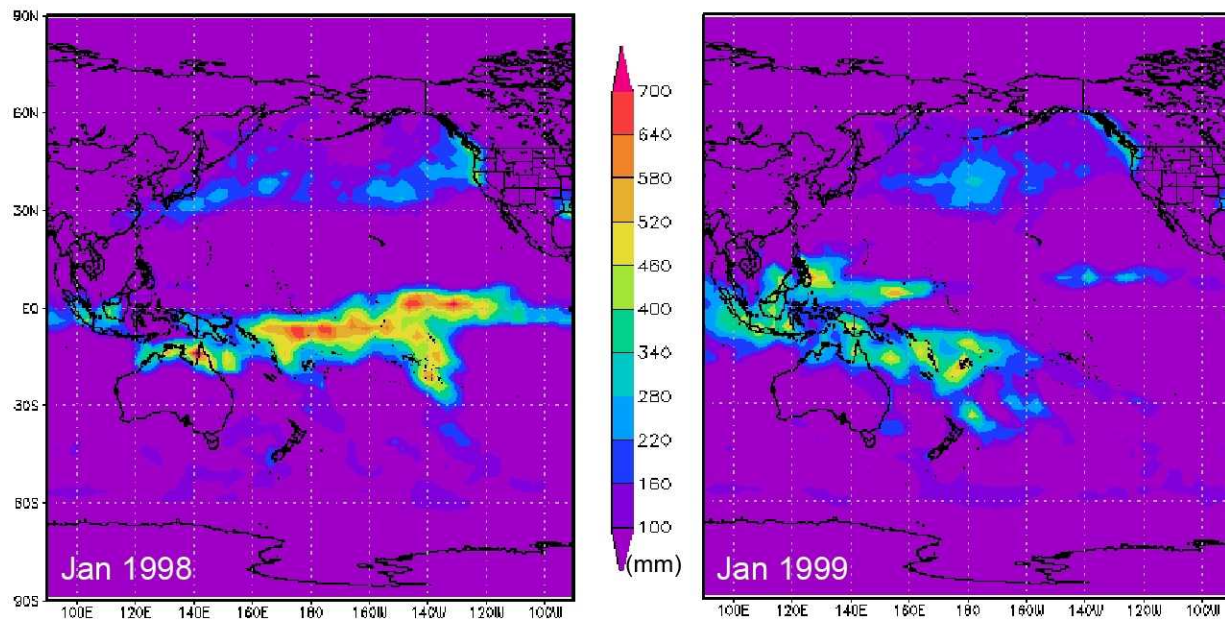


Example of GPCP precipitation accumulation (in mm) for the Pacific Ocean sector in September 2009. The Intertropical Convergence Zone runs east-to-west just north of the Equator. The South Pacific Convergence Zone extends southeastward from the Equator east of Australia, while mid-latitude storm tracks are located south of Australia and east of Japan. The heavy precipitation in Southeast Asia is part of the Asian Monsoon.





Precipitation (in mm) accumulated for the period 01-07 October 2009 in the northwestern Pacific as estimated by the TRMM 3B42RT. During this time Typhoon Melor tracked from the area east of the Marianas Islands to the coastal waters south of Japan. Melor attained supertyphoon strength in the middle of its lifetime. However, the heaviest accumulations occurred at the beginning and end of the period, when Melor was not a supertyphoon.



Back-to-back strong El Niño and La Niña events in 1998 and 1999 created dramatically different precipitation patterns over the tropical Pacific Ocean (shown here for Januaries from the GPCP monthly estimates). The El Niño focuses precipitation along the Equator, while the La Niña shifts precipitation reinforces dry conditions along the Equator and heavy precipitation to the west, north, and south.